Apollo Main 15 Parachute Failure

Your severity for Apollo Failure is too high given the level of redundancy.

- cc also high - bow

→ see John's notes

Thorough but
Lack of original work

→ References for these historical failures?

that you pulled the info from

Item/Function

- Apollo Main Parachute System
  - Risers
  - Suspension Lines
  - Canopy
Potential Failure Mode

- Damage found on risers and suspension lines
  - Caused canopy to fail
- Normal dumping of fuel during descent
  - Caused being exceeding temperature limits for risers and suspension lines

Potential Effects of Failure

- Loss of 1 entire effective canopy
- Only 2 were required for safe operation
- Increased velocity on splashdown
- Less comfortable
- Severity: 7
Potential Causes

- Anomaly report found likely cause to be RCS fuel expulsion during descent
  - RCS system is used to stabilize entry, but not entire fuel reserve is utilized
  - Excess fuel is dumped before splashdown

Occurrence

- Based on the number of failures on operational Mercury, Gemini, and Apollo missions: **Occurrence: 8**
- Total number of parachutes:
  - Mercury (piloted launches): 6
  - Gemini: 10
  - Apollo (including Apollo-Soyuz): 15 x 3 = 45
- Number of failures: 1
- Occurrence ≈ 17 per thousand vehicles
Current Controls and Detection

- **Prevention**: Time delay for propellant expulsion
- **Detection**: Visual methods. Retrieval helicopters, mothership, and capsule crewmembers visually identified failure event, *Detection 10*

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RPN and Recommended Actions

- **RPN Score**: 560 Need to decrease Severity, then Occurrence, then Detection scores
- Increase amount of oxidizer in propellant
- Increase time delay before RCS thrusters turn off and fuel dumps
- Create orientation sensor to avoid dumping during parachute alignment with RCS thrusters
- Add thermal sensors on risers to take action if temperatures increase beyond limits prior to failure
Responsible Party and Actions to be taken

- Responsible Person:
  Failure Investigation Committee Chair: **John Christian**
- Complete by: February 1972

1. Increase time delay from 42 to 61 seconds
2. Increase ratio of oxidizer to fuel
3. Conduct Additional Tests
4. Add thermocouples to risers

Severity 4
Occurrence 4
Detection 3
New RPN: 48
<table>
<thead>
<tr>
<th>Item/Function</th>
<th>Potential Failure Mode</th>
<th>Potential Effects of Failure</th>
<th>Severity</th>
<th>Potential Causes/ Mechanisms of failure</th>
<th>Occurrence</th>
<th>Current Controls</th>
<th>Detecti</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apollo Main Parachute System</td>
<td>Damage to the riser, suspension line, and canopy, from exceeding temperature limits due to raw fuel expulsion during the tank depletion firing during descent.</td>
<td>Loss of entire canopy causing higher velocity impact. Potential damage to vehicle, injury to crew members dependent on number of canopies damaged.</td>
<td>7</td>
<td>Raw fuel expelled from RCS system as venting during descent.</td>
<td>8</td>
<td>Prevention: Time delay for propellant expulsion Detection: By visual methods; ground crew, Apollo crew saw the parachute burning</td>
<td>10</td>
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<td>Genesis Parachute System</td>
<td>The parachutes didn't deploy because no trigger from the G-Switches was given.</td>
<td>With no parachute deployment, Genesis had no deceleration, resulting in a complete loss of the vehicle. The vehicle crashed at 200 mph and broke apart.</td>
<td>8</td>
<td>The G-Switches were installed backwards as specified in the Lockheed-Martin designs. This resulted in an opposite sign on the acceleration vector, which did not trigger the mortar fire.</td>
<td>10</td>
<td>Prevention: Systems Engineering methods design reviews. Assumed function due to heritage. Detection: System testing. Inspection of workmanship. Sensor based detection system to account for lack of mortar firing and chute deployment. Visual methods from helicopter crews. (Crash was filmed)</td>
<td>6</td>
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<tr>
<td>PN</td>
<td>Recommended Actions</td>
<td>Responsibility and Target Completion Date</td>
<td>Action Taken</td>
<td>Sev</td>
<td>Occ</td>
<td>Det</td>
<td></td>
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<td>60</td>
<td>- Increase time delay of rapid propellant dump. Increase amount of oxidizer in the RCS in order to mitigate the damage that would be done by the propellant. - Create a sensor that would detect the orientation of the main chutes in comparison to the vents and make sure that venting does not occur when a chute is in the path of the vent. - Add thermal sensors to risers, suspension lines, and canopy to provide early warning.</td>
<td>Responsible Person: Failure Investigation Committee Chair, John Christian</td>
<td>- Increased the time delay of the rapid propellant dump from 42 seconds to 61 seconds. - Increased the ratio of oxidizer to propellant. - Conduct Additional Tests. - Add thermocouples to risers to detect temperature increases that will shut down the RCS dumping.</td>
<td>4</td>
<td>4</td>
<td>3</td>
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<td>Completion Date: February 1972</td>
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<td>(Damage caused by leaked fuel is mitigated by higher oxidizer mix. Damage caused will be within tolerance of riser strength)</td>
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<td>80</td>
<td>- Overhaul project Systems Engineering methods to make certain that small issues are not overlooked. - Avoid assuming that heritage can be applied directly without any analysis. - Understand heritage components and their requirements. - Use redundant system for parachute deployment in case an error occurs in primary sensor.</td>
<td>Responsible Person: Failure Investigation Committee Chair, Dr. Wallace Fowler</td>
<td>- Systems Engineering methods revamped. - Future missions will conduct important centrifuge tests. - Corrected the orientation of the G-Switches. - Clarified requirements. - Add secondary method for parachute deployment.</td>
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<td>Completion Date: November 2004</td>
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<td>(given added redundancy) (Improved oversight should fix detected malfunctions) (Improved oversight should detect failure mechanisms)</td>
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